



On the depletion of HCl in the Antarctic polar vortex

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Satellite observations and numerical modeling are used to constrain the mechanisms that deplete gas-phase HCl in the Antarctic vortex. Our analysis shows that current formulations of heterogeneous chlorine activation cannot explain the observed loss of gas-phase HCl in SD-WACCM. Uncertainties in photochemistry, transport and initial conditions are investigated, and it is shown that ClONO₂ formed after photolysis of condensed-phase nitrate increases the loss of HCl through heterogeneous chemistry, especially in the sunlit edge of the vortex. This process eventually produces sufficient NO_x to completely deplete gas-phase HCl but this occurs too late compared to observations. Our results suggest that the more likely primary mechanism for decreases in gas-phase HCl from the beginning of the polar night until about the middle of July is active partitioning between the gas and condensed phase. Since the HCl taken up into particles is quickly released upon warming, it does not represent irreversible loss of chlorine, only temporary removal from the gas-phase. With HCl dissolved in STS particles, the associated decrease in gas-phase HCl is not an indicator of chlorine activation. The solubility of HCl in STS is highly sensitive to water vapor and temperature, such that accurate simulation of both is necessary to reproduce the observed depletion of gas-phase HCl. With the reference setup of SD-WACCM hardly any HCl is simulated to be sequestered in STS. A negative offset has to be applied to model temperatures to achieve significant partitioning of HCl into the condensed phase. While our results imply substantial changes in chlorine partitioning during the polar night, the ozone loss is insensitive to them.